ANALYSIS OF
POST-2004 PROJECT USE
OPERATIONAL ALTERNATIVES
FOR THE
CENTRAL VALLEY PROJECT

Prepared for

THE BUREAU OF RECLAMATION

By

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Analysis of Post-2004 Project Use
Operational Alternatives for the Central Valley Project

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Analysis of Post-2004 Project Use Operational Alternatives for the Central Valley Project

In light of changes in California's electric utility industry and future changes in the manner that the Western Area Power Administration (Western) intends to market its services and power from the Central Valley Project (CVP or Project), the Bureau of Reclamation – Mid Pacific Region (Reclamation) has retained Navigant Consulting, Inc. (Navigant Consulting) to examine certain operational alternatives for the CVP. The primary purpose of this analysis is to review potential alternatives for CVP operations that may provide additional value to CVP Water and Power customers in the post-2004 timeframe. Reclamation initiated the analysis at this time as a part of a more comprehensive process that has included a stakeholder working group of CVP Water and Power customers.

An important element of this analysis focuses on the approach used to serve "Project Use Loads" or the power requirements necessary to support the water pumping operations for irrigation purposes and other overall CVP system operations. At this time, Reclamation has requested that Navigant Consulting analyze two specific operational alternatives:

Alternative I Load Following: Project Use Loads met with CVP Resources
Alternative II Maximum Peaking: Project Use Loads met with Market Purchases

The analysis and valuation of each operational alternative will provide an estimate of the impacts of maximizing Project Use Loads.

<u>Introduction</u>

The Central Valley Project is a multi-purpose project consisting of a system of water storage and conveyance facilities designed to serve a variety of Project purposes, including, but not limited to power production, managing water use and deliveries for irrigation purposes, and meeting specific environmental requirements. The CVP generates power from a series of dams and reservoirs located in northern California. The CVP system of hydroelectric facilities generates power primarily for use by Reclamation in support of pumping requirements as well as the overall facility operation or Project Use Loads to ensure delivery of water to the Project's water customers. Historically, the generation from the CVP facilities has been assumed to be used first to meet Project Use Loads with the excess made available to Preference Customers such as municipal utilities, public power agencies, and other qualified customers to serve their loads.

As a result of the existing and long-standing integration agreement, Contract No. 14-06-200-2948A (Contract 2948-A) between Western and the Pacific Gas and Electric Company (PG&E), the operation of CVP facilities for meeting Project Use Loads and the corresponding power generation has been a less significant issue than what may likely be the case in the post-2004 timeframe. Currently, the integration agreement allows PG&E to schedule the CVP generation facilities as long as certain requirements are met, such as serving Project Use Loads. With the impending expiration of the integration agreement at the end of 2004, combined with California's developing electric marketplace, and Reclamation's desire to examine alternatives to serve the Project Use Loads and create additional value for CVP Water and Power customers, Project operations have come to the forefront. Therefore, it is important to examine at this time the manner by which the CVP is operated to achieve the greatest value from the Project while at the same time meeting the needs of the Project and complying with environmental guidelines.

Overview of Analysis

As briefly noted above, CVP system operations were examined for two specific operational alternatives: 1) Load Following and 2) Maximum Peaking. The difference between the two alternatives relates to the approach used to meet Project Use Loads. For the purposes of this analysis, under the Load Following alternative, Project Use Loads are met, to the extent possible, through CVP resources. The remaining "surplus" generation is then optimized and valued according to forecasted market prices of energy. Thus, this alternative provides for CVP generation schedules to take into account Project Use Loads. Under the Maximum Peaking Alternative, Project Use Loads are met through market purchases, with an estimate calculated for the valuation of the total available CVP generation. This alternative provides for CVP generation schedules to be developed independent of Project Use Loads. An estimate of the value of ancillary services is provided under each of the operational alternatives. An estimation of costs associated with Project Use Loads is also determined for each alternative.

Methodology and General Approach

The general approach used to provide an evaluation and comparison of the two operational alternatives consisted primarily of estimating the total market value of each alternative according to a forecast of market prices for electricity and ancillary services. For each alternative, the same operational requirements, including water releases, energy requirements, reservoir operating limits, plant capacities and outages, electric price forecasts, and Project Use Loads were used to ensure a valid comparison of results.

It is important to note that each operational alternative represents an optimization and valuation based on forecasted market prices of energy with CVP resources meeting Project Use Loads, to the extent possible, under the Load Following alternative, and Project Use Loads being purchased from the marketplace under the Maximum Peaking alternative using the same market price forecast. It is also important to recognize that this analysis does not attempt to provide a comparison between existing CVP operations to a Maximum Peaking operational approach, rather a comparison of alternatives for serving Project Use Loads.

The methodology used to make the evaluation and comparison of operational alternatives employs a series of daily model information based upon CVP operational data. The focus of this analysis is to translate the daily operational requirements (water releases and generation) into an hourly generation schedule of each CVP hydroelectric generation facility and to provide an estimate of market value of the energy produced.

A key element of the analysis relates to dispatching generation facilities for “surplus” energy and then estimating the value of the resulting energy, ancillary services, and Pacific Northwest import requirements. The analysis places a priority on dispatching generation against forecasted market prices for energy. This element of the analysis allows for each CVP facility to be operated in parallel to the highest priced periods for each day. Under the Maximum Peaking alternative, the total water release requirements are dedicated to generating power during the highest priced periods of the day with requirements for Project Use Loads being purchased from the marketplace. Under the Load Following alternative, water releases are scheduled to first meet Project Use Loads, with the remaining or “surplus” being used to generate power during the higher priced periods of the day.

Once the hourly generation schedules are developed for each operational alternative, the availability of ancillary services is then determined. The type of ancillary services provided is taken into consideration as part of the analysis:

regulation being provided first, followed by spinning reserves and then non-spinning reserves in order of priority. An estimate of the valuation of each ancillary service is determined by applying the available ancillary service to a forecast of market prices.

Components of Analytical Model

The analysis and valuation of each of the operational alternatives is based on a foundation of CVP operational data, modeling assumptions, and criteria relating to the water-year operating conditions. The analysis can be summarized into three basic components.

- CVP Operational Data
- Electricity Market Price Forecast
- Generation Optimization and Valuation

Each of these three components are outlined and discussed in more detail below.

CVP Operational Data. The model operational data used in the operational analysis was developed based on ProSim computer runs and actual historical CVP operational data for each of the CVP hydroelectric generation and pumping facilities. Three operating scenarios were developed for reviewing each of the operational alternatives in dry, median, and wet hydrologic-year conditions. For each of these hydrologic conditions, an actual operating year was selected to best fit the simulated computer runs. After reviewing the output from the ProSim computer runs, the data was then matched and assigned to a particular historical water year. The following historical years were selected:

1992 – Dry water year
1985 – Median water year
1986 – Wet water year

These representative water years were then used to develop typical water release and generation schedules to determine plant outage schedules for the CVP facilities, and to determine the Project Use Load requirements. The resulting operational data was primarily daily generation information with Project Use Loads and facility outage data available on an hourly basis. The daily water and generation schedules were the basis for developing hourly generation schedules to optimize system generation within the day for each of the operational alternatives.

Market Price Forecast. A second component of the analysis included the development of an hourly electric price forecast. The electric price forecast was developed in a two-step process. The output from a production simulation run was used to develop a base case forecast of generating units and incremental operating facilities in the Western Systems Coordinating Council (WSCC) area. This base case analysis has been used in a number of studies of energy prices in the WSCC area. For the purpose of this analysis, the summary output is used in a spreadsheet model which calculates electric market prices based on forecasted estimates of natural gas prices, the addition of new generating facilities in California, as well as historical price relationships in the California electric marketplace.

The electric price forecast is based on natural gas generating facilities as the incremental unit with natural gas prices estimated for northern and southern California. New generating unit construction was also estimated based on proposals submitted to the California Energy Commission. Based on these results, the estimated average annual market prices were extrapolated to monthly and later broken down to hourly prices based on historical market data in California. It is important to note that a specific electric price forecast was developed for each of the hydrologic-water year conditions.

In developing hourly prices for the purposes of this analysis, the forecast is based on market conditions and perceptions prior to June 2000 when the California electric marketplace experienced significant price spikes and supply shortages. While these more recent market trends are significant, it was felt at this juncture that it was too early into this market transformation to develop a revised forecast for five years into the future to reflect this recent volatility.

Generation Optimization and Valuation. A third component of the analysis includes an optimization and valuation routine. The valuation of CVP generation was performed under each operational alternative. For each of these operational alternatives, the analysis was completed for three hydrologic conditions: dry, wet, and median-year water conditions. The results were measured according to the market value of the generation based on the hourly market price forecast. Figures 1 and 2, shown below, summarize the specific steps followed to optimize CVP generation and estimate the value of CVP resources under each of the operational alternatives.

FIGURE 1
"MAXIMUM PEAKING ALTERNATIVE"
DESCRIPTION OF OPTIMIZATION AND VALUATION

Step	Description of Routine
1	Identification of Operational Data (Daily Energy, Daily Water Releases, Plant Capacities, Reservoir Operation Limits)
2	Development of Hourly Electric Price Forecast and Identification of Highest Optimal Price Block
3	Development of Water Release Profile that Accounts for Operation Data and Optimal Price Block for Hourly Electric Price Forecast
4	Develop Hourly Water Release Pattern According to Water Release Profile
5	Convert Hourly Water Release Pattern into Generation using Generation Ratios from Operational Data
6	Apply Generation Schedule to Hourly Electric Price Forecast to Estimate the Market Value of Energy
7	Determine Availability of Ancillary Service based on Generation Schedule and Hourly Plant Capacity Figures
8	Apply Available Ancillary Services to Price Forecast to Estimate Value of Ancillary Services
9	Calculation of Project Use Requirements (Energy and Ancillary Services)

FIGURE 2
"LOAD FOLLOWING ALTERNATIVE"
DESCRIPTION OF OPTIMIZATION AND VALUATION

Step	Description of Routine
1	Identification of Operational Data (Daily Energy, Daily Water Releases, Plant Capacities, Reservoir Operation Limits)
2	Development of Hourly Electric Price Forecast and Identification of Highest Optimal Price Block
3	Development of Water Release Profiles that Account for Operation Data and Optimal Price Block for Hourly Electric Price Forecast, as well as Project Use Loads
4	Develop Hourly Water Release Patterns for Project Use Loads and "Surplus" Water and According to Water Release Profile
5	Convert "Project Use" and "Surplus" Water Releases into Generation using Generation Ratios from Operational Data
6	Apply "Surplus" Generation Schedule to Hourly Electric Price Forecast to Estimate the Market Value of "Surplus" Energy
7	Determine Availability of Ancillary Service based on Generation Schedule and Hourly Plant Capacity Figures
8	Apply Available Ancillary Services to Price Forecast to Estimate Value of Ancillary Services
9	Calculation of Project Use Requirements (Energy and Ancillary Services)

Based on the steps described for each of the operational alternatives, the analysis resulted in a valuation for the energy and capacity from each CVP hydroelectric-generation facility. The operating limits for each facility are built into the analysis to limit the operations according to governing criteria. Limitations and requirements were established for each CVP facility with daily water schedules used as a target for optimizing generation from the facility. If the water release from the facility was set at 8,000 acre-foot based on the CVP operational data set, then this amount of water (and corresponding generation) was optimized within the day according to various operating limits. The key operating limits used for each of the CVP facilities included:

- Generating unit capacity
- Generating unit outages
- Reservoir operating limits

For each day, these parameters were used to determine an optimal market value that can be derived from the available generation within the day. Under the Load Following alternative, an additional parameter used to optimize generation was Project Use Loads. In this alternative, estimated water release amounts (and corresponding generation) were held back and used first to meet energy requirements for Project Use Loads prior to optimizing the "surplus" generation (generation available in excess of Project Use Load requirements) according to forecasted market energy prices.

The valuation of CVP generation was calculated for both energy and ancillary services. The analysis was developed to optimize the value of energy according to hourly market prices of energy. Based on the generation schedules developed as a part of the optimization routine, the availability of ancillary service capacity was calculated and valued according to market prices. The ancillary services were determined in the order of their historical market value and included in the total valuation of the CVP Resources. The ancillary services included:

- Regulation
- Spinning reserves
- Non-spinning reserves

Other ancillary services for voltage support, replacement reserves, and black start are neither active nor significant markets and, as a result, were not measured for the purposes of this analysis. Under each of the operational alternatives, the market valuation of both energy and ancillary services were estimated using the same approach.

Project Use Loads. As a part of determining the net value of each of the operational alternatives, Project Use costs were also taken into account. To determine the net market value of each alternative, applicable market purchase costs for energy to serve the Project Use Loads offset the calculated valuation of CVP resources. Under the Maximum Peaking alternative, costs associated with Project Use Loads are represented by the total costs of purchasing the energy and ancillary service requirements in the marketplace. Under the Load Following alternative, the costs associated with Project Use Loads are represented by the additional amount of energy and ancillary service requirements that needed to be purchased from the market.

Summary of Results

The analysis and evaluation of each of the operation alternatives illustrates increased value for the Maximum Peaking alternative. As shown in Figure 3, the overall estimate of value between each of the operational alternatives ranges from approximately $1.5 million to $2.8 million annually for the Maximum Peaking alternative. This represents an increase in the value of the CVP generation after all Project Use Load requirements (energy and ancillary services) are met by market purchases. This optimization of CVP generation results in rescheduling of about one-quarter of the Project Use Load energy requirements.

It is important to note that this analysis did not attempt to compare the value of optimizing CVP generation facilities versus current CVP operations, but rather provide a comparison of two potential alternatives. The parameters for this analysis were fairly conservative and did not exhaust all potentially reasonable optimization opportunities. The goal of this comparative analysis was to ensure that environmental and water delivery constraints or requirements were satisfied before any hourly optimization routines were implemented. There were a number of opportunities that were not examined as part of this current analysis. These opportunities, in some cases, were not identified in the study process and in other cases, were viewed as too uncertain or time consuming at this juncture to pursue further. Some of these opportunities include CVP operations under more volatile market conditions, optimization of the market valuation in the selection of ancillary services or energy according to market prices, and further optimization of regulating reservoir operations. Nonetheless, the current analysis demonstrates that even under very conservative river management and water release requirements that the overall CVP system can be operated in a manner that increases the net value of the system to the CVP Water and Power customers.

FIGURE 3
SUMMARY OF RESULTS
MAXIMUM PEAKING VERSUS LOAD FOLLOWING

	Wet-Year		Median-Year		Dry-Year	
Category	MP ($)	LF ($)	MP ($)	LF ($)	MP ($)	LF ($)
Energy	244,562,602	209,946,434	197,787,149	149,039,741	124,666,354	103,025,635
Ancillary Services	35,701,755	35,311,814	36,008,776	36,032,483	27,368,569	27,534,703
Project Use Costs	33,699,124	171,466	46,097,682	185,079	23,939,190	4,542,078
Net Value	246,565,233	245,086,782	187,698,243	184,887,145	128,095,733	126,018,260
Variance (MP-LF)	**1,478,451**		**2,811,098**		**2,077,473**	

Although Figure 3 provides an overall summary of the results of the operational analysis, detailed results of the analysis, which provide facility-specific and monthly information, are provided in the Appendix of this report. A list of material included in the Appendix is also provided.

APPENDIX I
LIST OF TABLES FOR OPERATIONAL ANALYSIS

Table	Description
1	Summary of Analysis for each Operational Alternative and Water Year – Dollars
2	Detailed Summary of Analysis for each Operational Alternative and Water Year – Energy and Dollars
3	Detail of Energy Analysis for Maximum Peaking Alternative – Wet Year Water Conditions
4	Detail of Energy Analysis for Load Following Alternative – Wet Year Water Conditions
5	Detail of Energy Analysis for Maximum Peaking Alternative – Median Year Water Conditions
6	Detail of Energy Analysis for Load Following Alternative – Median Year Water Conditions
7	Detail of Energy Analysis for Maximum Peaking Alternative – Dry Year Water Conditions
8	Detail of Energy Analysis for Load Following Alternative – Dry Year Water Conditions
9	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Regulation) – Wet Year Water Conditions
10	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Spinning Reserves) – Wet Year Water Conditions
11	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Non-Spinning Reserves) – Wet Year Water Conditions
12	Detail of Ancillary Services Analysis for Load Following Alternative (Regulation) – Wet Year Water Conditions
13	Detail of Ancillary Services Analysis for Load Following Alternative (Spinning Reserves) – Wet Year Water Conditions
14	Detail of Ancillary Services Analysis for Load Following Alternative (Non-Spinning Reserves) – Wet Year Water Conditions
15	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Regulation) – Median Year Water Conditions
16	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Spinning Reserves) – Median Year Water Conditions
17	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Non-Spinning Reserves) – Median Year Water Conditions
18	Detail of Ancillary Services Analysis for Load Following Alternative (Regulation) – Median Year Water Conditions
19	Detail of Ancillary Services Analysis for Load Following Alternative (Spinning Reserves) – Median Year Water Conditions
20	Detail of Ancillary Services Analysis for Load Following Alternative (Non-Spinning Reserves) – Median Year Water Conditions
21	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Regulation) – Dry Year Water Conditions
22	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Spinning Reserves) – Dry Year Water Conditions

Table	Description
23	Detail of Ancillary Services Analysis for Maximum Peaking Alternative (Non-Spinning Reserves) – Dry Year Water Conditions
24	Detail of Ancillary Services Analysis for Load Following Alternative (Regulation) – Dry Year Water Conditions
25	Detail of Ancillary Services Analysis for Load Following Alternative (Spinning Reserves) – Dry Year Water Conditions
26	Detail of Ancillary Services Analysis for Load Following Alternative (Non-Spinning Reserves) – Dry Year Water Conditions
27	Detail Cost of Ancillary Services for Project Use Loads – Wet Year Water Conditions
28	Detail Cost of Ancillary Services for Project Use Loads – Median Year Water Conditions
29	Detail Cost of Ancillary Services for Project Use Loads – Dry Year Water Conditions

APPENDIX II
DETAILED RESULTS OF MODEL ANALYSIS